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Executive Summary: Large Wood in the Upper Chattooga River Watershed, November 2007

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Prepared January 2008

During the week of November 12th 2007, personnel from the Southern Research Station's Center for Aquatic Technology Transfer (CATT), Francis Marion-Sumter National Forest, and Chattahoochee-Oconee National Forest conducted an inventory of dead and down large wood (LW) in the upper Chattooga River, West Fork Chattooga River, and two tributaries of the West Fork Chattooga River. Crews counted all wood larger than 1 m long and 10 cm in diameter that had the potential to influence stream channel shape and function (Table 1); in practice this meant all wood that impinged on the bankfull channel. Crews used a global positioning system to delineate consecutive stream reaches of 0.5 km and maintained separate tallies of wood for each reach. Individual large wood accumulations and other features such as slides and slumps were noted and photographed with digital cameras. Flow at the time of the inventory was near base conditions, enabling crews to wade the entire stream channel. We summarized our results using a geographic information system for ease of interpretation (Figure 1). The raw data have been tabulated and are accessible either electronically or in written format.

From November 13-15 we walked 26.4 miles of the Chattooga and West Fork (Table 2). The Chattooga mainstem had 205 and the West Fork 357 pieces of LW per mile of stream channel. As is typical, the LW tended to be located along stream margins, channel bends, and on sediment bars and in a few small jams.

Table 1. Size categories used for LW inventories in the Chattooga River watershed, November 2007. All LW within the bankfull channel were recorded.

Size Class	Length (m)	Diameter (cm)
1	1 - 5	10 - 55
2	1 - 5	> 55
3	> 5	10 - 55
4	> 5	> 55

Table 2. Total LW counts from streams inventoried in November 2007.

River	Start Location	Length (miles)	Total LW	LW per mile
Chattooga	confluence with West Fork Chattooga	20.4	4171	205
West Fork Chattooga	confluence with mainstem Chattooga	6.0	2154	357
Holcomb Creek	Three Forks	2.7	1446	529
Overflow Creek	Three Forks	2.9	551	193

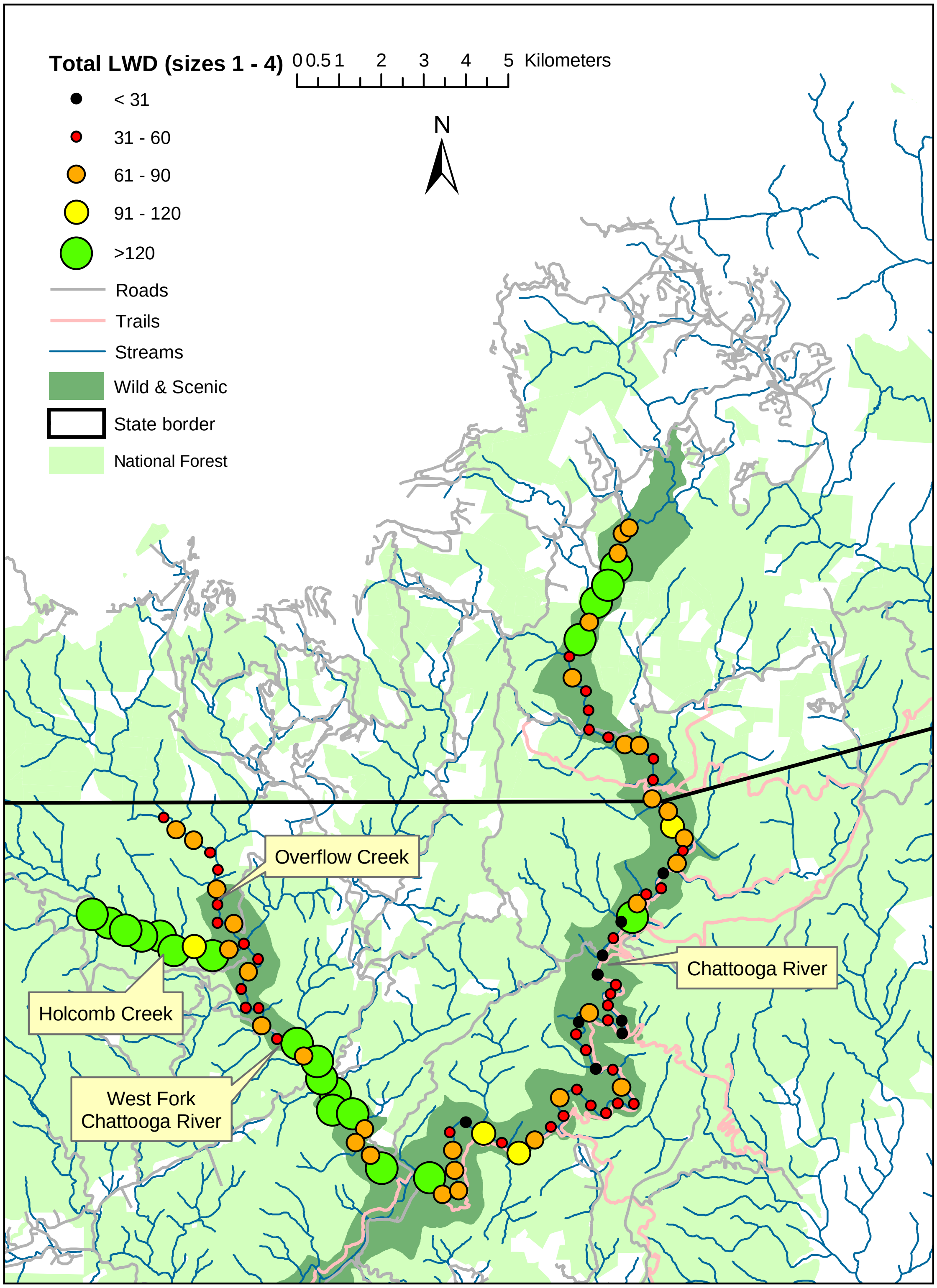

Figure 1. Counts of LW in 0.5 km reaches on the upper Chattooga River watershed, November 2007.

One notable exception to the general pattern of LW distribution was a very large jam on the upper river in North Carolina, which occupied the entire channel to a height of 18-20 feet (Figure 2). Wood in this jam was in various states of decay and disintegration, suggesting that it had accumulated over many years. This jam is unique; jams of this size are unusual in the southeastern US, where as a result of past human activities most streams carry small loads of LW.

Figure 2. Large wood jam on the upper Chattooga River, North Carolina, November 2007

Much of the relatively larger LW load in the West Fork Chattooga appears to be derived from past logging in the West Fork drainage. Many if not most of the LW pieces were logs as evidenced by two saw-cut ends and typical saw-log lengths. These logs tended to form major portions of the banks along the mid-lower West Fork channel.

Although many of the LW pieces found in Holcomb Creek were likely also residual from logging as evidenced by saw-cut ends, none of the cuts were recent. At least some of the pieces in the lower half of Holcomb Creek probably had broken loose from an old splash dam[1], located about 0.5 km downstream of the bridge on FS road 86b. Comparison of recent photos with others taken in 1989 suggest that while the base of the dam is largely intact at the upper end, many logs have become detached from the lower end and transported various distances downstream (Figures 3 – 4).

[1] Constructed about 1915, this dam was constructed from logs cut on site and used for several years to facilitate floating and movement of logs harvested in the watershed. The remaining base is a log crib-work held together by iron spikes of about 1” diameter and 12-18” length


Figure 3. Upper end of splash dam in 1989 (left) and 2007 (right).

Figure 4. View across splash dam on Holcomb Creek, West Fork Chattooga River, November 2007.

Large wood loads in Holcomb and Overflow Creeks, two major tributaries of the West Fork Chattooga, were notably different. At 193 pieces per mile, Overflow Creek had the lowest LW load of all reaches surveyed. Holcomb Creek, on the other hand, had the highest load at 529 per mile.

We also have included the results from a 1989 LW inventory conducted in Holcomb and Overflow creeks. These data were collected as part of a larger study of fish habitat and production conducted during the late 80's - early 90's. In contrast to the 2007 inventory wherein all wood in the bankfull channel was counted, LW in 1989 was tallied within the wetted channel only. This means that we cannot examine changes in the amount of LW between 1989 and 2007. However, we were able to compare LW loads between streams within each year. In 1989 there were 34 and 96 pieces per mile in Overflow and Holcomb, respectively. In both 1989 and 2007 Holcomb had about 2.5x more total wood than Overflow (Figure 5).

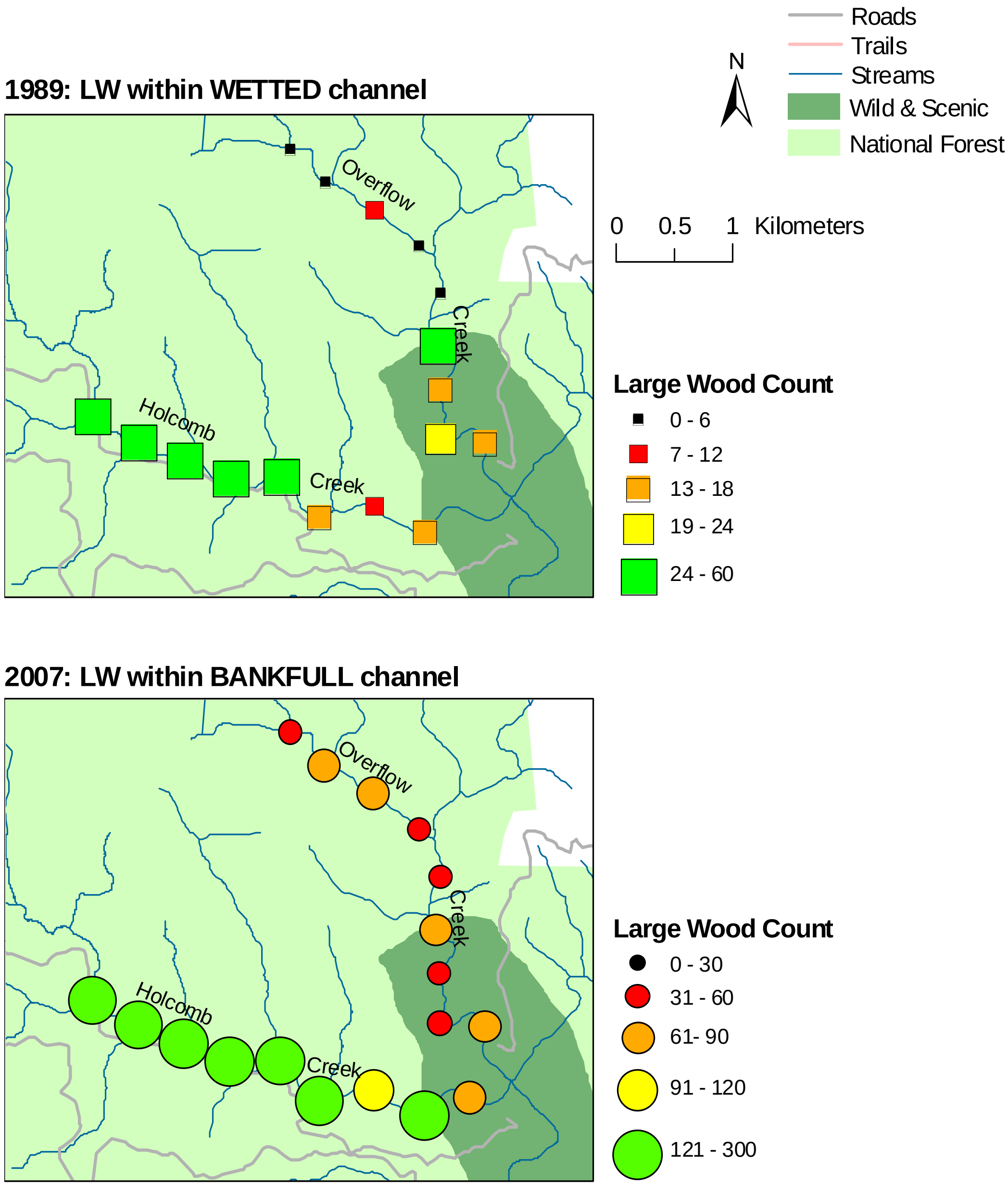

Figure 5. Large wood counts in 0.5 km reaches on Overflow Creek and Holcomb Creek in 1989 and 2007. In 1989, pieces within the wetted channel were counted. In 2007, pieces within the bankfull channel were counted.

The large number of LW pieces exhibiting saw-cuts is an indication that human intervention is at least one of the reasons for the dramatically lower LW load in Overflow Creek (Figures 6 – 9). While a portion of the LW in Overflow Creek probably represented residual pieces from logging conducted in the last century, some of the cuts were very recent; we found an empty motor oil container among the rocks at Three Forks near the confluence of Holcomb and Overflow creeks, where we also observed and photographed a channel-spanning hemlock and maple that had been sectioned into smaller pieces. Sawdust and small cut branches were present at this site, which was a plunge pool immediately below a small waterfall.

Figure 6. Freshly cut wood found near Three Forks, November 14, 2007.

Figure 7. Freshly cut wood found near Three Forks, November 14, 2007.

We noted several additional locations on the mainstem Chattooga and Overflow Creek where pieces of LW had been cut or removed from the stream channel. The age of the cuts varied from several days to several years. Several of the targeted pieces were channel spanners that provide measurable benefit to streams in the form of sediment and organic debris retention.

Figure 8. Cut wood suspended above wetted channel on Overflow Creek, November 2007.

Figure 9. Partially submerged cut wood found in Overflow Creek, November 2007.

Wood is an important feature of streams flowing through forested areas. In particular, large wood and other obstructions such as boulders slow flow, trap sediments, and damp and delay flood peaks. Tree boles are major pool forming elements and wood contributes to aquatic habitat in diverse ways such as by providing cover from predators, refuge from high velocity flow, and substrate and organic matter for macroinvertebrates. Large wood is considered so beneficial that riparian forests today are managed for LW inputs and where recruitment or loading is judged insufficient; LW is intentionally added to stream channels.

Wood loads tend to be lower in streams disturbed by human activities such as logging and land clearing, both because wood has deliberately been removed and because forested riparian areas have not recovered sufficiently to replenish the supply of dead and down large wood. In the eastern US, streams flowing through previously logged wilderness areas have lower wood loads than streams draining undisturbed wilderness. Similarly, the Chattooga Wild and Scenic River corridor exhibits signs of its logging history and thus is in a state of recovery. Paradoxically, LW loads in Holcomb Creek are uncharacteristically high at least in part due to residual pieces left from logging and recent disintegration of a splash dam.

Wood naturally enters stream channels by various avenues including bank undermining or blowdown of individual trees or groups of trees and transport en masse in debris flows or landslides from upstream channels or adjacent riparian areas. Although logging was one of the more dramatic causes of large wood loading and subsequent decline, other human influences such as roads and trails, and land clearing for any reason have influenced both the rate and amount of large wood entering streams. Other more insidious events also can lead to variation in the rate of LW recruitment. Since the beginning of the previous century a fungus, inadvertently brought to North America on nursery stock from Asia, has killed nearly all American chestnut trees. American chestnut was a dominant tree throughout much of the eastern US where, except for areas of salvage, its demise resulted in higher than expected rates of large wood and debris recruitment.

The distribution and abundance of LW we documented in November 2007 is similarly a reflection of both past and present day disturbances within the Chattooga River watershed and while the impacts some disturbances are known, the effects of others are yet to be seen. The watershed contains thousands of hemlock trees, the majority of which exhibit varying states of degrees of damage from the hemlock wooly adelgid. As was the case with American chestnut, it appears that nearly all affected trees die. We documented several hemlocks that already have died and been recruited as LW pieces (Figures 10-11).

The ongoing drought in the southern US also will contribute to the increasing rate of wood recruitment. Trees, particularly those already stressed by insects or disease, are further weakened by extreme weather conditions and thus susceptible to windthrow or high precipitation events. It seems likely that even relatively mild storm events will contribute to increased slope failures and tree toppling over the next few years. While it is not possible to predict the total number of pieces that ultimately will be recruited, regular monitoring will reveal the extent of these LW and other organic material additions and will help determine the degree to which depleted wood loads in the Chattooga River watershed are replenished.

Figure 10. Recently fallen hemlock in mainstem Chattooga, November 2007.

Figure 11. Recently fallen hemlocks in Overflow Creek, November 2007.

Inventory of Large Wood in the Upper Chattooga River Watershed, November 2007

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Introduction

Wood is an important feature of streams flowing through forested areas. In particular, large wood (LW) and other obstructions such as boulders slow flow, trap sediments, and damp and delay flood peaks (Montgomery et al. 2003). Tree boles are obvious major pool forming elements but wood contributes to aquatic habitat in diverse ways such as by providing cover from predators, refuge from high velocity flow, and substrate and organic matter for macroinvertebrates (Benke and Wallace 2003, Dolloff and Warren 2003). Large wood is considered so beneficial that riparian forests today are managed for LW inputs (Boyer et al. 2003, Jacobs 2004) and where recruitment or loading is judged insufficient, LW is intentionally added to stream channels (Reich et al. 2003).

Wood naturally enters stream channels by various avenues including bank undermining or blowdown of individual trees or groups of trees and transport en masse in debris flows or landslides from upstream channels or adjacent riparian areas (Swanson 2003). Although logging was one of the more dramatic causes of large wood loading and subsequent decline, other human influences such as roads and trails and land clearing for any reason have influenced both the rate and amount of large wood entering streams (Nakamura and Swanson 2003). Other more insidious events also can lead to variation in the rate of LW recruitment. Since the beginning of the previous century a fungus, inadvertently brought to North America on nursery stock from Asia, has killed nearly all American chestnut (*Castanea dentate*) trees. American chestnut was a dominant tree throughout much of the eastern US where, except for areas of salvage, its demise resulted in higher than expected rates of large wood and debris recruitment (Hedman et al. 1996). Today, the hemlock wooly adelgid (HWA) (*Adelges tsugae*), an aphid-like insect from Japan threatens eastern hemlock (*Tsuga canadensis*) with a similar fate (Koch et al. 2007).

The Chattooga River originates in North Carolina and flows south, forming part of the border between South Carolina and Georgia. Its watershed contains portions of the Francis Marion-Sumter (FMSNF), Chattahoochee-Oconee (CONF), and Nantahala National Forests (NNF), as well as the Ellicot Rock Wilderness Area (Figure 1). Like much of the forested land in the eastern US, the Chattooga River watershed experienced extensive logging in the early 1900s (Hedman et al. 1996, Manganiello 2006). In 1974, Congress designated 57 miles of the upper Chattooga River and a major tributary, the West Fork Chattooga River as ‘Wild and Scenic’ to preserve their outstanding natural and cultural resource values. The watershed receives heavy recreational pressure from several nearby population centers, including Atlanta, GA (Jacobs 2004) and has been infested by HWA since 2001 (USDA Forest Service 2007). Hemlocks are a primary component of the riparian forest throughout much of the watershed and are in a rapid state of decline (pers. obs.).

In fall 2007, the FMSNF contacted the Southern Research Station (SRS), Center for Aquatic Technology Transfer (CATT) to request assistance in development and execution of a LW inventory in the upper Chattooga River watershed (upstream of the West Fork Chattooga River confluence). The CATT collaborated with SRS scientists and resource specialists from the FMSNF and CONF to design and implement a LW inventory for selected stream reaches of the Chattooga River, West Fork Chattooga River (hereafter referred to as West Fork), Overflow Creek, and Holcomb Creek. During the week of November 12th 2007, personnel from the CATT, FMSNF, and CONF conducted an inventory of dead and down LW in the selected stream reaches. Crews counted all wood larger than 1 m long and 10 cm in diameter that had the potential to influence stream channel shape and function; in practice this meant all wood that impinged on the bankfull channel. Our primary goal was to describe the current abundance and distribution of LW within the selected reaches. Our data also provide a baseline for future LW monitoring efforts in the watershed.

Methods

Inventory Sections

The FMSNF requested an inventory of LW on 32.8 km of the mainstem Chattooga River from its confluence with West Fork to the Forest boundary near the confluence with Green Creek (Figure 1, Table 1). The majority of lands in the Wild and Scenic corridor between Green Creek and road 1107 near Grimshawes are in private ownership, precluding extension of the inventory upstream of Green Creek. The CONF requested an inventory on 9.7 km of the West Fork from its confluence with the Chattooga River to Three Forks (confluence of Holcomb Creek, Overflow Creek, and Big Creek). We also conducted inventories on 4.6 km of Overflow Creek and 4.4 km of Holcomb Creek for comparison with data collected on these streams as part of a larger study of fish habitat and production conducted during the late 80's - early 90's. Each inventory section was divided into consecutive 0.5 km reaches, as described below.

Reach Delineation

We acquired high resolution (1:24,000) National Hydrography Dataset stream data for the Chattooga River watershed and used an Arcmap extension (Beyer 2004) to locate points at the upstream extent of selected stream sections and every 0.5 km downstream thereafter (Figure 1). When the furthest downstream reach was 300 m long or less we joined that reach with the reach immediately upstream. When the furthest downstream reach was greater than 300 m long we allowed the reach to remain separate. As a result, of the 102 total reaches we delineated, 98 were exactly 0.5 km, 3 were longer, and 1 was shorter. The output was saved as a point shapefile. We converted the point shapefile to a series of waypoints using a second Arcmap extension (Minnesota Department of Natural Resouces 2001) and loaded the waypoints onto Garmin eTrex Vista CX GPS[1] units.

[1]use does not imply endorsement

Field Work

Two-person crews entered the stream, located their assigned section, and then waded through each 0.5 km reach, tallying all pieces of LW that partially or wholly lay within the bankfull channel. Both crew members classified and counted pieces of LW. We recorded pieces of LW by size class (Table 2) and kept separate counts for each 0.5 km reach. In addition, we tallied rootwads and obstructions, observed riparian condition, photographed stream features, and recorded relevant comments. Rootwads were counted separately from attached pieces of LW. For example, if we encountered a size 4 piece of LW with a rootwad attached we tallied 1 piece of size 4 and 1 rootwad. We defined obstructions as single pieces or accumulations of LW that spanned at least half of the bankfull channel. Wood jams consisting of multiple pieces of LW counted as a single obstruction. We classified riparian condition as: 1) mostly forested; 2) mostly open; or 3) mixed forest/open. Crews recorded data on electronic datasheets. All data were stored in an Access database and exported to Excel and ArcMap for analysis.

Results

All streams were at very low discharge levels (USGS flow gauge near Clayton, GA was below 140 cfs for duration of inventory), allowing us to wade the majority of the stream channel. We inventoried 51.5 km of stream (Table 1) and recorded 8322 total pieces of LW (Table 3). At 329 pieces per km Holcomb Creek had the highest total LW per km, while neighboring Overflow Creek had the lowest, at 120 pieces per km (Table 4). Examination of individual 0.5 km reaches showed the highest total LW loads in Holcomb Creek, lower West Fork, and upper Chattooga River, lower loads in Overflow Creek and upper West Fork, and the lowest loads in the middle reaches of the Chattooga River (Figure 2). In most streams total LW was nearly equally split between the two small diameter size classes (sizes 1 and 3). Notable exceptions to this trend include Overflow Creek, where we found relatively few pieces of short, small diameter LW (size 1) (Table 5, Figure 3), and upper West Fork, which had relatively few long, small diameter pieces (size 3) (Table 5, Figure 5). We encountered the highest amounts of the larger diameter size classes (sizes 2 and 4) in the West Fork and upper Chattooga River, but overall these size classes were rare (Table 5, Figures 4 & 6).

We tallied 4 rootwads per km and 1 LW obstruction per km (Table 6). Rootwads were attached to less than 3% of LW pieces. Holcomb Creek had the highest number of both rootwads and obstructions per kilometer (Table 6, Figure 7). We classified all reaches as ‘mostly forested’ on Overflow Creek, and

Holcomb Creek. A single reach on the Chattooga River was classified 'mixed forest/open' with the remainder 'mostly forested'. Four reaches in lower West Fork were 'mixed forest/open with the remainder classified as 'mostly forested'. We noted hemlocks with varying states of hemlock wooly adelgid damage on all streams and documented fallen hemlocks in several reaches. We also noted pieces of cut wood in all streams. Cuts ranged in age from several days to several decades (Tables A2, A3, B2, B3, C2, C3, D2, D3).

We also have included results from a 1989 LW inventory conducted in Holcomb Creek and Overflow Creek. These data were collected as part of a larger study of fish habitat and production conducted during the late 80's - early 90's. In contrast to the 2007 inventory wherein all wood in the bankfull channel was counted, LW in 1989 was tallied within the wetted channel only. This means that we could not examine changes in the amount of LW between 1989 and 2007. However, we were able to compare LW loads between streams within each year. In 1989 there were 34 and 96 pieces per mile in Overflow and Holcomb, respectively. In both 1989 and 2007 Holcomb Creek had about 2.5x more total wood than Overflow Creek (Figure 8).

Discussion

We documented high variability in LW loads both within and among stream sections in the Chattooga River watershed. The smallest size class (size 1) comprised nearly half of the total LW load. The Chattooga River watershed is in a state of recovery from disturbance resulting from extensive logging in the early 1900's. Riparian forests in the southeast, even those managed as wilderness, provide minimal LW for at least 100 years after disturbance (Flebbe and Dolloff 1995, Hedman et al. 1996, Hornbeck and Kochenderfer 2000). During this period of low wood recruitment streams are particularly sensitive to LW removed during localized natural (e.g. floods) or human related (e.g. targeted removal) disturbances. Variation in scope and magnitude of these localized events and the presence of a high amount of small, easily transported pieces results in high amounts of variation in LW loads among and within streams.

In the period from 100 - 150 years after disturbance riparian forests mature and overstory mortality increasingly contributes LW (Hedman et al. 1996). Most of the Chattooga River watershed is entering this period when extant riparian forests become significant sources of LW. Hemlocks play an increasingly important LW role as riparian stands transition from this mid-successional period into late-successional and ultimately old-growth conditions. Hemlocks are shade-tolerant allowing them to grow in mixed riparian stands with a dense rhododendron (*Rhododendron maximum*) understory, as is common in the southeast (Ellison et al. 2005). Large fallen hemlocks are relatively stable, particularly in smaller stream channels (Nakumura and Swanson 1994), and slow to decay (Hedman et al. 1996, Ellison et al.

2005). Unfortunately, the majority of hemlocks in the watershed will die from HWA infestation over the next several years and much like the American chestnut, its days as a LW contributor are numbered.

The ongoing drought in the southern US will only serve to hasten their demise. Trees, particularly those already stressed by insects or disease, are further weakened by extreme weather conditions and thus are susceptible to windthrow or high precipitation events. It seems likely that even relatively mild storm events will contribute to increased slope failures and tree toppling over the next few years. In the short-term this will result in increased LW loads, though the ultimate amount is difficult to predict with precision. The long-term effect in many areas will be to reset the clock on riparian forest succession. Although *Rhododendron* likely will become the dominant riparian species where it is already established in the understory, in other areas hardwoods and yellow poplar (*Liriodendron tulipifera*) will replace hemlocks (Ellison et al. 2005). But it will be decades, if not centuries before the riparian forests can again provide significant amounts of LW. In the interim the streams will remain sensitive to LW removal and rely heavily on carry-over LW.

Carry-over LW are pieces that persist in the stream channel following their initial input. We counted many carry-over pieces of LW on Holcomb Creek and upper West Fork, left behind by loggers in the early 1900’s. These pieces had two saw-cut ends and were typical saw log lengths, placing most of them in size category 3 (>5 m long, 10 – 55 cm diameter). Some had broken free from a disintegrating splash dam located about 0.5 km downstream of the bridge on FS road 86b. Others had likely remained in place for decades. In portions of the West Fork the logs were embedded in the stream banks. Holcomb Creek and West Fork had 2 – 3 times more size 3 LW per km than Chattooga River or Overflow Creek, where we saw no evidence of carry-over from logging activities. Results from our 1989 inventories on Overflow Creek and Holcomb Creek suggest that carry-over LW has elevated loads in some streams for decades. As hemlocks are recruited to the LW load they have the potential to contribute carry-over benefits for hundreds of years (Hedman et al. 1996).

Clearly carry-over LW has the potential to provide long-term benefits to streams in the Chattooga River watershed. Conversely, removal of LW can have long-term detrimental effects. We documented several locations on the Chattooga River, Overflow Creek, and upper West Fork where pieces of LW had been cut or removed from the stream channel. On the mainstem Chattooga the cuts were often near dispersed camping areas. We did not see evidence of camping on Overflow Creek or upper West Fork but the reach is a popular whitewater boating run (American Whitewater 2006). The cuts ranged in age from several days to several years. The most recent cuts were on a newly fallen, channel spanning hemlock and maple in upper West Fork. The LW had been cut into small, easily moved pieces. Some pieces had been placed outside of the bankfull channel. Pieces that are removed from the channel can not function as LW and will not soon be replaced, an unintended consequence that will span generations.

The Chattooga River watershed faces many management challenges in the coming years. Recreation pressure will continue to increase and the HWA infestation will radically alter riparian and stream ecology. Regular monitoring will enable Forest Service managers to document LW input and carry-over during and after the HWA infestation. We recommend annual inventories for the duration of the infestation and following storm events and regular monitoring every 3 – 5 years thereafter.

In summary, our inventory found:

1) variability in the amount and distribution of LW within the upper Chattooga River watershed;

2) potential for large amounts of hemlock inputs from HWA caused deaths;

3) need to protect carry-over LW due to long-term loss of a dominant riparian species;

4) need to monitor LW inputs and removal.